1
ξφ−νM/σα
{ω/φν}<σ
ξφ−νM/σα
6
PLANVIEW@S400 3.72

# 2.0 BUILDING A HIGH-SPEED TRAIN NETWORK

## 2.1 Route and Alignment

The Authority continued with the work of the High-Speed Rail Commission to evaluate alternative routes for a high-speed train system that will meet the travel demands of California residents for the year 2020 and beyond. The objective was to serve all major population centers projected to exist in 2020 and high-speed travel markets anticipated for that time period.

In preparing a sound financial plan, it is necessary to select a complete system that meets the basic objective of serving the 2020 and beyond travel markets effectively and efficiently, while maximizing user revenues and minimizing public (non-user) contributions.

Cost estimates were based on five percent engineering analysis at a conceptual planning level. Investment quality travel demand, ridership and revenue estimates were made. Based on the results of these analyses and current available data, the Authority selected the alignment represented in *Figure 2.1* as the “highest projected return on investment route” to be used in preparation of the full-funding scenario presented in Chapter 6.

This “optimum” system represents the best investment opportunities based on currently available information, but does have shortcomings and uncertainties that require further investigation. It does not provide service to Orange County in the south nor to the East Bay Area in the north. It does not serve Los Angeles International Airport (LAX), the state’s largest airport, or Palmdale, a potential regional airport, and it may adversely impact agricultural land in the Central Valley area.

In order to further optimize the alignments, to address potential shortcomings, and to develop a more accurate cost figure based on a more refined level of engineering, the Authority recommends several additional corridors be investigated in the next phase of work, which is the environmental clearance process. Final alignments should not be selected at least until the conclusion of a state program level Environmental Impact Report (EIR) and/or federal Tier I Environmental Impact Statement (EIS). Based on work conducted thus far, the Authority is confident that should any one of the alternative corridors be selected, a high-speed train system can be constructed and financed within the limits of the full funding scenario. It is also possible that as demand for service grows, some alternative routes may become viable segments to be constructed. By completing the program EIR on these routes, the option of building more than one route will be available. *Figure 2.2* represents the corridors that should be included in the environmental assessment based on data available at this time. A final


Figure 2.1
**Highest Return on Investment Route**


Figure 2.2
**Recommended Routes to be Studied in the Environmental Clearance Phase**

decision on alignment prior to the completion of additional studies would not be prudent.

The station locations described in this section were identified as the most likely sites based on current knowledge and are consistent with the objective to serve the major population centers of the state in 2020. There is, of course, a critical tradeoff between the accessibility of the system to potential passengers and the resulting high-speed train travel times. The station locations shown here are spaced approximately 50 miles apart in rural areas and 15 miles apart in the metropolitan areas. Additional or more closely spaced stations would negatively impact travel times and the ability to operate both express and local services.

Several key factors were considered in identifying potential station stops. These include speed, cost, local access times, potential connections with other modes of transportation, and the distribution of population and major destinations along the route. Again, the ultimate locations and configurations of stations cannot be determined until the conclusion of the environmental clearance process.

A description of each segment of the high-speed network is provided below:

## Los Angeles — San Diego

High-speed train service for major population centers, including Los Angeles, Orange and San Diego counties and the Inland Empire is essential and must be included in the high-speed train system. Two viable and potentially inclusive routes can meet the need. Both routes would start from Los Angeles Union Station and terminate in San Diego and would provide direct service from north of Union Station to San Diego without requiring a transfer at Union Station.

**The station locations are spaced approximately 50 miles apart in rural areas and 15 miles apart in metropolitan areas.**

One option would include a coastal alignment that modifies the existing LOSSAN rail route. This option would include stations at Norwalk, Anaheim, Irvine, University Town Center and downtown San Diego. The other option is on an alignment going east from Union Station to the Inland Empire using existing rail rights-of-way with stations at East San Gabriel Valley, Ontario Airport, and Riverside. This Inland Empire option would continue south from Riverside using the Interstate 215/Interstate 15 highway corridor to San Diego with stations at Temecula and Mira Mesa, and would terminate in San Diego near Qualcomm Stadium. Both options produce similar ridership and revenues, but the coastal alignment is estimated to cost less to construct.

The coastal option, while promising to be less costly and therefore a better capital investment, requires major modifications to the existing right-of-way as well as approval from the cities and communities along the route. The Federal Railroad Administration (FRA) will need to grant an exemption to allow the high-speed line to share track with other trains in the corridor. Given the potential of this corridor, the coastal option should continue to be evaluated in the environmental process, along with the second option, which has been selected for the funding scenario.

Given the importance of service to communities along the coast, the Authority recommends that the environmental studies along the LOSSAN Corridor also consider improvements to achieve the highest possible speed and capacity improvements consistent with environmental constraints and community support. Highest priority should be given to improvements between Los Angeles Union Station and Anaheim. If high-speed service on this corridor is not feasible, conventional rail should be improved to increase speed and capacity to provide the highest level of service possible. The Authority would work with Amtrak to make the LOSSAN Corridor a high-speed Amtrak corridor and to secure federal funding for the necessary improvements.

The state has received a Federal Railroad Administration (FRA) planning grant to conduct the necessary engineering and environmental work to compete for a potential federal construction grant for a Maglev line serving Los Angeles International Airport (LAX), Union Station, Ontario Airport, and March Airport in Riverside. This project is a joint effort of the Business, Transportation and Housing Agency, the Southern California Association of Governments, and the Authority. Should this project prove feasible and move forward toward construction, it would satisfy the need for service to LAX as well as the Inland Empire. Depending on the type of technology selected for the rest of the network, travelers to and from other regions may need to transfer from one train to another at Union Station to complete their journey. Therefore, the environmental studies for these corridors should be coordinated, with the objective of producing a single alignment and technology for this segment of the network.

## Service to Los Angeles International Airport (LAX)

It is important that the state's largest airport, projected to have an annual passenger demand of nearly 100 million in 2010, have a direct and convenient link to the high-speed train system. This corridor is currently being studied as a potential Maglev corridor. Therefore, while this link is not included in the Authority's financial plan, service to this airport should continue to be investigated and evaluated for steel-wheel-on-steel-rail and Maglev technologies in the program EIR.

## Tehachapi Crossing: Union Station — Bakersfield

From Union Station to Santa Clarita, the Metrolink right-of-way will be utilized with potential stations at Burbank Airport and Santa Clarita. North of this, one of the major challenges for a statewide high-speed train system is the connection from Santa Clarita to Bakersfield. Two viable options for this corridor exist. One follows Interstate 5 (I-5) over the Grapevine, which includes 28 miles of tunnels, and the other is a line through the Antelope Valley with a station at Palmdale. The Antelope Valley alignment, which crosses the Tehachapis through the Mojave Pass, will be 41 miles longer than the I-5 route option but includes only 11 miles of tunnels.

Engineering and planning analyses by the Authority, the High-Speed Rail Commission, and Caltrans show that both options are feasible. Based on the results of engineering and other analyses to date, the I-5 Corridor would cost $700 million less to construct and produce higher annual ridership with lower operating costs. Therefore, the Authority, using cost and ridership as its primary criteria, selected the I-5 route to be used for the funding scenario.

The Authority recognizes, however, that the I-5 route decision may change as a result of further technical studies and analyses performed during the environmental process, along with other factors, including, but not limited to, airport development, changes in regional growth patterns, and cost sharing with local entities, developers or airports. Therefore, the Authority recommends that both corridors be evaluated equally through the environmental assessment phase and that final selection of a preferred alignment be made at the conclusion of that phase.

## Central Valley: Bakersfield — Merced

Among the four corridors evaluated by the Authority, the West of State Route 99 alignment, which was recommended by the High-Speed Rail Commission, has the lowest cost and fastest travel times, and yields higher ridership and revenue. Using cost and ridership as the primary criteria, the Authority selected this corridor with stations at Bakersfield, Visalia, Fresno and Merced to be used for the funding scenario.

This corridor could have a greater impact on prime agricultural land, however, and it does not easily serve either downtown Fresno or downtown Bakersfield, which are those cities' preferred station location sites. The Authority therefore recommends that the environmental assessment also consider the following refinements to this alignment:

- Options to minimize the impacts to prime agricultural lands;
- Options to serve a downtown station or airport in Fresno;
- Options to serve a station close to the county seat and government center or airport in Bakersfield; and
- Options to utilize existing rail corridors.

Recognizing that the success of a high-speed system is highly dependent on travel time, the objectives of any refinements to this corridor should be: 1) to negotiate with right-of-way owners and local officials to select an alignment that can maximize the use of existing transportation corridors; and, 2) to meet the needs of local and regional entities without incurring unnecessary costs to the state or increasing express service travel time. In order for the stations to be located downtown, the Authority and city officials must jointly agree on station location, parking, traffic, circulation and revenue and cost sharing.

## Bay Area Access

The optimum corridor for serving the San Francisco Bay Area is an alignment from south of Merced through the Pacheco Pass, in the vicinity of State Route 152. This alignment would head west from the State Route 99 corridor north of Fresno. From Gilroy to San Jose, the alignment would utilize the existing Caltrain rail corridor. Potential station sites include Los Banos, Gilroy, and San Jose.

## San Jose — San Francisco — Oakland

Direct service from San Jose to Fourth and Townsend streets in San Francisco along the San Francisco Peninsula produces higher ridership and revenue than an alternative from San Jose to Oakland. The Peninsula alignment utilizes the Caltrain right-of-way and would also permit a direct connection to the region's hub airport at SFO. Therefore, this alignment, with stations at Redwood City and SFO, has been selected for the funding scenario.

Service to the East Bay is, and will be, an important component of a successful intercity passenger train network. Therefore, the Authority recommends that both the San Jose — Oakland segment and the San Jose — San Francisco segment be included in the environmental assessment phase and that the final decision on how to serve these key regional cities be made at the conclusion of that work. In addition to the environmental studies for a high-speed corridor, options for increasing speed, frequency and reliability of conventional rail in the Capitol Corridor, particularly San Jose to Oakland, should be evaluated.

Termination at the Transbay Terminal in San Francisco should also be included in the environmental studies. This option would be subject to the Transbay Terminal being designated as a regional bus and transit hub, the Authority and the City and County of San Francisco reaching agreement on the construction and use of the terminal, and the Authority and the Caltrain Joint Powers Authority reaching agreement on shared use of right-of-way.

## Central Valley: Merced — Sacramento

The optimum alignment for this segment would ollow the State Route 99 corridor to the downtown terminus in Sacramento. A new rail corridor would extend from Merced to a station in Modesto along the State Route 99 corridor, to the outskirts of

Sacramento. Existing rail right-of-way would be used through Sacramento to the downtown terminus. A station to the east of State Route 99 would serve Stockton.

## 2.2 Implementation Process and Construction Phasing

Neither construction of the system nor selection of a specific alignment can take place until completion of the environmental review process, as specified by California and federal law. Because of the complexity and geographic scale of the project, the implementation is expected to take 16 years from the start of the environmental review process to full operation *(Figure 2.3)*. Specific revenue-producing segments could, however, potentially be completed and opened for revenue service earlier in the implementation schedule. The overall implementation process for the high-speed train system can be divided into three phases, as described below.

### Phase 1: Conceptual Planning

This phase was initiated by the California High-Speed Rail Commission, continued by the Authority, and will be complete with the submission and acceptance of this business plan.

### Phase 2: Environmental Review and Preliminary Engineering

This next phase of implementation will include both a broad, program-level environmental review process as well as a project-specific environmental analysis. The next step toward implementation will be to prepare a program level EIR/EIS. The program level environmental process will address the cumulative impacts of the statewide high-speed rail program. The process will also focus on the environmental analysis of each of the corridor alternatives to identify alignments that are considered feasible by local, state, and federal agencies with approval or permit responsibilities. Alignment and station locations will be further refined, a detailed construction phasing plan prepared, and engineering design completed up to the 10 percent level during this process. Upon completion of the program level EIR/EIS, the Authority will have the ability to purchase or preserve some of the right-of-way for the system. The program level EIR/EIS is expected to take up to two years and $25 million ($1999) to complete.

Project-specific environmental reports and preliminary engineering will commence during the implementation phase following the program level EIR/EIS. This four-year period would involve project-specific environmental analyses and preliminary engineering for discrete segments of the system; preparation of procurement documents for construction, operations, and maintenance; and finalization of the construction staging plan. The engineering designs would be completed up to the 30 percent level at the end of this phase.

### Phase 3: Final Design and Construction

Final design and construction will begin upon the completion of the environmental process and preliminary engineering of a discrete segment of the system. Assuming the use of a design-build procurement approach, construction of the system could be completed within 10 years. Specific revenue-producing segments could be completed and opened earlier in the implementation schedule. For example, a core segment from Los Angeles to San Francisco could potentially be completed at the end of the seventh year with completion of the remaining segments to follow.

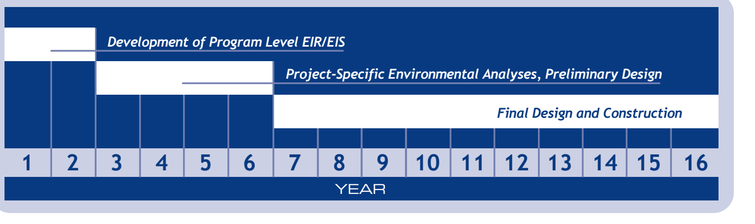


Figure 2.3
**Implementation and Construction Timeline**

## 2.3 Capital Costs

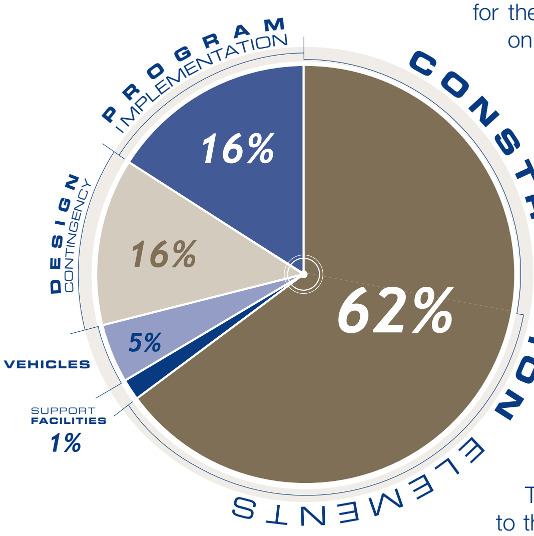


Figure 2.4
**Capital Cost Breakdown**

The construction cost estimates and travel times presented for the high-speed train system assume steel-wheel-on-steel-rail technology because Maglev systems have not been constructed or operated for regular revenue service. The technology assumed is the "next generation" anticipated to be available within the implementation time frame. These assumptions were made in order to identify reasonable and deliverable performance characteristics and costs. The design criteria and performance characteristics presented in this section do not imply a recommendation on technology. The actual selection of technology and equipment manufacturer will be made as part of the system procurement process.

The high-speed train system is expected to cost $25 billion to construct in 1999 dollars. The cost per mile for the system varies according to the difficulty of the terrain and constraints on the right-of-way, varying from about $12 million per mile to over $70 million per mile in urbanized areas *(Table 2.1)*.

The total capital cost estimate includes all costs involved between the present time and the opening of the high-speed train system. These include construction costs, program implementation, vehicle costs, and support facilities. As shown in *Figure 2.4*, the bulk of the costs are in civil and construction work, to be done in California. Even portions of the trainsets that account for the remaining five percent of the total cost could be manufactured in California. Construction costs include stations, track work, earthwork, structures, grade separation, right-of-way acquisition, environmental impact mitigation, rail and utility location, signals and communications infrastructure, and electric power supply and distribution. As shown in *Figure 2.5*, structures account for over a quarter of the construction cost, with grade separation and right-of-way accounting for another 17 and 12 percent, respectively.

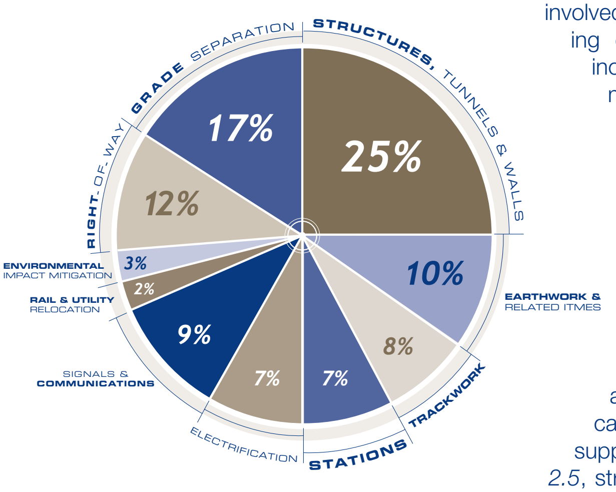


Figure 2.5
**Construction Cost Breakdown**

Some of the specific items of note in the cost estimate include fencing along the entire right-of-way and barriers where necessary for separation from incompatible rail traffic. The cost estimate also includes a contingency, calculated as 25 percent of the construction costs, as well as an allowance for environmental impact mitigation, calculated at 3 percent of the construction cost.

The Authority is confident that the capital cost estimates presented here will be sufficient to construct a high-speed train system. Many of the cost components involved, such as electrification, signaling, rail, and track bed are quantities well known from rail projects around the world. The costs for major civil works, including tunneling and structures, are specific to California's geology, seismic conditions, and labor markets. Previously completed civil projects in California, including freeway construction, major water projects, urban rail projects, and preliminary engineering work done for the Los Angeles to Bakersfield segment of the network (Caltrans, 1994), all provide guidance on these more specialized costs. Thus, capital costs can be estimated with a high degree of confidence even though the statewide engineering has proceeded only to the conceptual planning level.

| SEGMENT | LENGTH (MILES) | CAPITAL COST (BILLIONS, $1999) | AVERAGE COST / MILE (MILLIONS, $1999) |
|---|---|---|---|
| San Diego - Riverside | 92 | 4.1 | 44.5 |
| Riverside - Los Angeles | 59 | 2.7 | 45.7 |
| Los Angeles - Bakersfield | 110 | 4.4 | 40.0 |
| Bakersfield - Merced | 160 | 2.3 | 14.4 |
| Merced - Sacramento | 110 | 3.0 | 27.3 |
| Merced - San Jose | 129 | 4.5 | 34.8 |
| San Jose - San Francisco | 43 | 2.5 | 58.1 |
| SUBTOTAL | | $23.5 | |
| Vehicles & Support Facilities | | 1.5 | |
| TOTAL | 703 | $25.0 | $37.8 |

Table 2.1
**Capital Costs by Segment**

## 2.4 Operating Scenario, Travel Times and Operating Costs

### Service Plan

The conceptual operating plan takes advantage of the high-speed infrastructure's potential capacity and flexibility to offer a wide variety of service options. A mix of express, semi-express, local and regional trains would serve both intercity passengers and long-distance commuters.

In 2020, a total of 86 weekday trains in each direction will be needed to serve the statewide intercity travel market. Sixty-four of the trains will run between northern and southern California and the remaining 22 trains will serve shorter distance markets.

The basic service pattern provides most passenger service between 6:00 a.m. and 8:00 p.m., with a few trains starting or finishing trips beyond these hours. Five types of intercity trains are planned, including:

- Express (20 trains/day) — Trains running between Sacramento, San Jose or San Francisco and Los Angeles or San Diego without intermediate stops.
- Semi-Express (12 trains/day) — Trains running between Sacramento, San Jose or San Francisco and Los Angeles or San Diego with intermediate stops at major Central Valley cities such as Modesto, Fresno and Bakersfield.
- Suburban-Express (20 trains/day) — Trains running locally within the major metropolitan areas at the beginning and end of the trip (i.e., the San Francisco Bay Area and the Los Angeles area) without intermediate stops in the Central Valley.
- Local (12 trains/day) — Trains stopping at all stations. Some of these local trains might ultimately be operated as a "skip stop" service to improve the service and better match patterns of demand.
- Regional (22 trains/day) — Sacramento to San Francisco service and early morning service from the Central Valley to San Francisco or Los Angeles/San Diego.

### Travel Times

The high-speed trains are projected to operate at speeds of up to about 220 mph *(Figure 2.6)*, making the travel times highly competitive with travel by air or auto. Travel between downtown San Francisco and downtown Los Angeles may be accomplished in just two-and-a-half hours. The trip between downtown Los Angeles and San Diego will take just an hour. *Table 2.2* shows additional samples of express travel times between cities.

The projected travel times account for alignment, train performance characteristics, acceleration and deceleration capabilities, and passenger comfort


Figure 2.6
**Average Operating Speed on High-Speed Train System**

| TRAVEL TIMES (HOURS:MINUTES) | Los Angeles | San Francisco | San Jose | San Diego | Sacramento | Fresno | Bakersfield | Riverside |
|---|---|---|---|---|---|---|---|---|
| Los Angeles | - | 2:30 | 2:02 | 1:00 | 2:09 | 1:19 | 0:47 | 0:29 |
| San Francisco | 2:30 | - | 0:31 | 3:29 | 1:40 | 1:15 | 1:47 | 2:58 |
| San Jose | 2:02 | 0:31 | - | 3:00 | 1:12 | 0:46 | 1:18 | 2:29 |
| San Diego | 1:00 | 3:29 | 3:00 | - | 3:07 | 2:17 | 1:46 | 0:34 |
| Sacramento | 2:09 | 1:40 | 1:12 | 3:07 | - | 0:53 | 1:25 | 2:36 |
| Fresno | 1:19 | 1:15 | 0:46 | 2:17 | 0:53 | - | 0:35 | 1:46 |
| Bakersfield | 0:47 | 1:47 | 1:18 | 1:46 | 1:25 | 0:35 | - | 1:15 |
| Riverside | 0:29 | 2:58 | 2:29 | 0:34 | 2:36 | 1:46 | 1:15 | - |

Table 2.2
**Express Travel Times**

criteria and have been verified by manufacturers of high-speed train equipment. The travel times include two minutes of dwell time at each station stop as well as a six percent schedule recovery time, consistent with European high-speed rail practice.

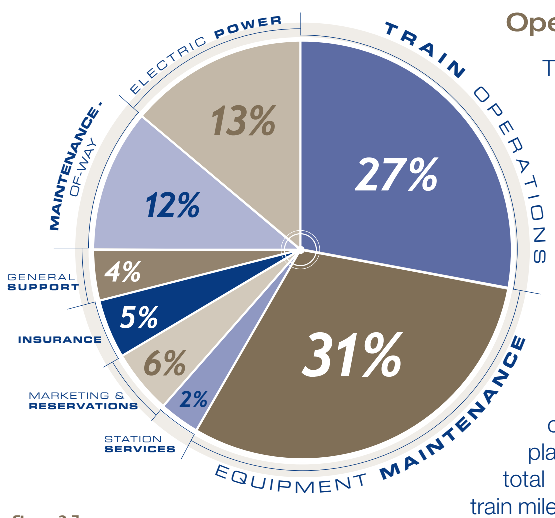


Figure 2.7
**Operating and Maintenance Costs**

## Operating Costs

The operating and maintenance (O&M) performance of systems in Europe, Japan and the U.S. Northeast Corridor are well known. Since the trainsets and tracks would utilize European or Japanese technology, costs for maintaining tracks and structures (including power systems and signaling) were based upon foreign experience. To estimate operational and maintenance costs for California, many of the components, most notably labor costs, were based upon Amtrak's Northeast Corridor service. The annual O&M costs associated with the conceptual service plan and used as inputs to the funding scenario total approximately $550 million for 24.2 million train miles per year. The largest O&M components are train operations and equipment maintenance. Both of these are very labor intensive and depend highly on the number of trains and the operating schedule. Maintenance-of-way and replacement costs for infrastructure and trainsets are included in the O&M costs. The O&M costs also include a variety of long-term costs including advertising, reservations, station services and general support. Electric power consumption accounts for the remaining major component of O&M costs. In total, the O&M cost per train mile is $22.70 for intercity operations *(Figure 2.7)*.

The high-speed train system would accommodate commute traffic in the San Francisco Bay Area (Los Banos — San Francisco), Los Angeles (Santa Clarita — Union Station and Temecula — Union Station), and San Diego (Temecula — Qualcomm) corridors with a relatively modest increase in operating costs. This is because long-distance commuters would ride the local and suburban express intercity trains already planned for operation in these corridors. The demand for high-speed, express commuter service could be accommodated with the addition of single passenger coaches on each train in most corridors. Only in the Los Angeles region would the level of demand require additional trainsets and additional runs. The incremental annual operating cost of serving commuters would be $31.8 million, by the year 2020. Revenues generated by the express commuters would, however, more than cover the incremental additional operating costs.

## Potential for Freight Service

High-speed trains could be used to carry small packages, parcels, letters or any other freight that does not exceed typical passenger loads. This service could be provided either in specialized freight cars on passenger trains or on dedicated lightweight freight trains. In either case, the lightweight freight vehicles would have the same performance characteristics as the passenger equipment. This type of freight could be accommodated without adjustment to the passenger operational plan or modification to the passenger stations and therefore has been included in the funding scenario.

A high-speed freight service might also be provided on specialized, medium-weight freight trains. This specialized freight equipment would have limited axle loads (19 metric tons compared to the conventional freight standard of 27 metric tons per axle), would operate at speeds of up to 125 mph, and would be scheduled at night in order not to compromise passenger or maintenance operations. The medium-weight freight service would carry high-value or time-sensitive goods such as electronic equipment and perishable items. Although this service would not interfere with passenger operations, it would require loading and unloading facilities separate from the passenger stations. Additional pick-up and distribution networks for this type of freight may also be required. Therefore, while the Authority recognizes the potential for overnight medium-weight freight service on the high-speed tracks, it has not been included in terms of potential additional costs or benefits. Discussions with potential high-speed freight operators will need to be initiated as part of the program EIR/EIS.



**The high-speed trains will operate at speeds of up to about 220 mph, making the travel times highly competitive with travel by air or auto.**